EXTENSION NOTE

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Establishing an Operational Trial of Soil Rehabilitation: Two Examples

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- **Operational trials provide an effective way to address information needs in soil rehabilitation.**
- **Operational trials also allow field staff and researchers to work cooperatively to provide relatively quick answers to questions. Operational trials provide researchers with a low-cost opportunity to evaluate, fine-tune, and expand existing scientific knowledge.**

INTRODUCTION

This Extension Note describes how operational trials can be used to address operational problems in forest soil rehabilitation in British Columbia. Two examples illustrate the steps involved in developing low-cost, reliable, and relevant operational trials of soil rehabilitation techniques.

WHY OPERATIONAL TRIALS ARE IMPORTANT

Applying science to operational problems is a necessary part of effective forest management. Solutions to problems can be sought through traditional experimental research trials, or through operational trials.

Operational trials are an important component of an adaptive management approach. Operational trials address the specific information needs of field staff, while also providing researchers with an opportunity to evaluate, fine-tune, and expand existing scientific knowledge. Operational trials also allow field staff and researchers to work cooperatively to provide relatively quick answers to immediately relevant questions. Some of the ways that operational trials (and adaptive management) are different from traditional research are described in the text box on the next page.

Although traditional and operational research findings have contributed to significant improvements of forest soil rehabilitation techniques in British Columbia in recent years, knowledge gaps remain. Throughout the province, more operational trials are needed to help forest managers improve soil rehabilitation techniques and meet the standards of the Forest Practices Code. Also, given that funding for soil rehabilitation research is very limited, operational trials are a cost-effective means of solving problems in a timely manner.

LOGISTIC CONSIDERATIONS

The combined total effort required by field staff to set up an operational trial can be as little as half a person day more than the operation would require. Research, forest sciences, and operational staff typically work together to contribute the extra effort required to set up, supervise, and monitor the trial. Summer students or B.Sc.(F) students working on theses are often interested in assisting with the set-up and reporting.

Good field installations are essential, so some extra effort is required to design treatments, lay out plots, and supervise equipment. Follow-up measurements and data reporting are relatively straightforward once a good trial is installed. Low intensity monitoring is inexpensive, but more detailed evaluations can be carried out if desired. Equipment and materials costs to establish a trial should be similar to typical operational costs for simply treating the area.

Four aspects need to be considered when establishing low-cost, reliable, and relevant operational trials, including:

1. Setting objectives.
2. Site selection and experimental design.
3. Supervise and document treatments.
4. Follow-up and reporting.

Setting Objectives

Trial objectives can be general or specific. Questions to be addressed through the scientific method are usually presented as a specific hypothesis that can be demonstrated to be false based on the data collected.

For operational trials, proposed treatments should have a chance to achieve reasonable results at reasonable cost. Some of the ques-

Is it Experimental Research, or an Operational Trial?

Experimental research trials and operational trials both aim to solve forest management problems using the scientific method. To fully understand ecosystem response to forest management, and to fully demonstrate sustainable forest development, experimental research trials are often needed. However, many operational issues can be resolved with less expensive operational trials.

Some differences between operational trials and experimental research projects are listed below.

Experimental trials	Operational trials
• Conceived and designed by researchers with consultation from operational staff. Most funding provided by researchers. Follow-up monitoring may involve considerable expense and commitment.	• Designed to directly address questions asked by operational staff. Funding provided by doing operational work. Follow-up monitoring may simply involve committing the time of forest science or operational staff.
• Often focus on issues of regional, provincial, national, or global concern.	• Focus on issues of immediate operational concern at the local or regional level.
• Short- or long-term studies, but short-term, operationally relevant products are often available even if the research has a long-term focus.	• Usually short-term studies, but long-term issues can sometimes be addressed. Most products are short-term and operationally relevant.
• In order to study ecosystem processes, some of the treatments studied may not necessarily make sense operationally.	• Treatments being tested are operationally relevant, and cheap, practical alternatives are often included in the trial.
• Experimental design incorporates strict requirements for replication and control plots to enable extrapolation of results. Treatments are usually randomly assigned to plots.	• Experimental design attempts to accommodate replication and controls within the operational setting. Logistics and efficiency are major factors affecting assignment of treatments.
• Simple and complex (more costly) measures of response; detailed measures investigate underlying processes that can be extrapolated to other areas.	• Usually use simple measures of response (tree survival, height). Results may be appropriate only for similar sites in the immediate area.

tions and hypotheses that could be addressed by operational soil rehabilitation trials are listed in Table 1.

Site Selection and Experimental Design

Site selection should focus on sites where work needs to be done as a requirement, or where other work is planned to address, for example, enhanced forest management or restoration objectives. The best trials are established when initial site conditions (i.e. at Silviculture Prescription level) are relatively uniform over the area to be treated, i.e. to facilitate accurate measurements of subsequent differences in tree growth. If initial site conditions are too variable, it may be best to pick another site.

An experimental design describes the treatment levels, the amount and type of replication, and the method of random assignment of treatments.[1] Research and forest sciences staff can assist forest managers in developing good experimental designs, including how to establish replicated treatments, and controls.

Supervising and Documenting the Treatments

To ensure that treatments are properly assigned to the plots, the work must be closely supervised by someone who fully understands the experiment and the layout plan. Although plans can change because of weather, equipment, or other factors, a good installation can still be achieved if all replicates of each treatment are the same, and any adjustments to the plan are documented in a complete set of field notes and photos.

Follow-Up Measurements and Reporting

Follow-up work on the site need not require much time, and can be as simple as observing or measuring the trees every few years, or conducting laboratory tests on soils and foliage.

Operational staff will get timely reporting of results by working closely with the forest sciences staff. Both parties can play a role in data collection, analysis, and reporting.

TWO EXAMPLES OF OPERATIONAL TRIALS

Following are examples of two successful operational trials that were set up to study soil rehabilitation techniques. The examples illustrate how pertinent questions can be answered relatively easily by superimposing a basic scientific study on an actual forestry operation. Both of these trials were established after researchers accompanied operational staff on a field tour of some of their problem sites. After discussing some typical restoration challenges, and viewing some sites where work was planned anyway, some proposed treatments were developed by the researchers. The machine work was supervised by Forest District staff.

Example 1: Lamb Creek (Cranbrook Forest District)

At the Lamb Creek site, landings and road segments in two blocks were scheduled for rehabilitation to restore growing sites because these roads and landings were no longer needed. The road in each block had some segments with a significant cutslope, and other segments where no significant excavation was required to build the road. Large piles of debris and stumps were adjacent to the landings and were scheduled for fall burning prior to the landing being rehabilitated by an excavator. Large amounts of ash and burned soil were expected to remain adjacent to the landings after the piles were burned. The intent of rehabilitation was to re-establish a commercial forest.

Lamb Creek is located in the ICHmw2, in an area of SiL to SL acidic soils derived from glacial till.

[1] Linnell Nemec, A.F. 1998. "Design of Experiments" pp 9-18 in *Statistical Methods for Adaptive Management Studies*. Editors V. Sit and B. Taylor. Land Management Handbook 42. BC Ministry of Forests, Victoria.

Table 1. Examples of questions and hypotheses.

General questions	Specific questions	Hypotheses *
Do rehabilitated sites support trees?	Are the trees on a particular landing surviving and growing at the same rate as those growing in nearby undisturbed soils?	Trees on the landing are surviving and growing at the same rate as those growing in nearby undisturbed soils.
Is it beneficial to conserve and re-spread topsoil?	On a particular landing where topsoil was conserved, are the trees growing at the same rate as those growing on nearby landings that were simply ripped?	Trees on the landing without topsoil are growing at the same rate as those growing on the landing with topsoil.
Is it feasible to restore soil productivity, or should roads and landings be considered permanent access even if they are not needed in the future?	How do the costs and benefits of soil rehabilitation compare to costs and benefits associated with site preparation?	For rehabilitation treatments that cost the same as site preparation, trees on rehabilitated landings are growing at the same rate as those growing on nearby areas that were site prepared.

* It is usually much easier to determine whether or not a hypothesis is false, so research questions are often framed that way.

Setting Objectives

• Road rehabilitation. Short sections of road in cutblocks are often rehabilitated; many questions surround this activity.

General Question: One general question that could be asked is:

"What are the benefits of rehabilitating roads in this area?"

Specific Questions: The general question was addressed by focusing the study on two specific questions:

1. *For sections of road with a significant cutslope*, what are the growth rates of trees planted on areas that have been fully re-contoured compared to growth rates on areas that are simply decompacted?

2. *For flat sections of road built without excavation*, what are the growth rates of trees planted on areas that have been decompacted, compared to growth rates on areas that were simply planted as is?

• Landing rehabilitation. Landing debris piles are commonly burned, so the study examined the benefits of using the ash and burned soil from the debris pile as a soil amendment, which may have some (though not all) properties similar to topsoil and fertilizer.

General Question: The general question that could be asked is:

"What are the benefits of tillage and using the burned soil and ash as a soil amendment for rehabilitation in this area?"

Specific Question: The general question was addressed by focusing the study on the following specific question:

1. Compared to growth rates on areas that were simply planted as is, what are the growth rates of trees planted on landing areas that have been:

(a) decompacted alone,

(b) decompacted plus amended with a thin (7-cm) layer of ash / burned soil, or

(c) decompacted plus amended with a thick (15-cm) layer of ash / burned soil?

Site Selection and Experimental Design

Four road segments were identified in each cutblock: two segments in areas of deeper cutslope, and two in areas with shallower or no cutslopes. Landings were split into four or five treatment plots. Because the two blocks were close together and had similar soil properties, the treatments on each landing and road segment were applied to one plot in each cutblock, giving two replicates of each treatment.

Two disturbance types required treating:

1. Roads
— Road cut / fill sections on sloping ground
— Roads without a cut bank on gentle ground

2. Landings, generally without a significant cutbank

The study included four treatments to restore soil productivity and grow trees as described in Table 2.

Treatments A through D were applied to both landings, to give two replicates of each landing treatment. A single replicate of the costlier, full recontouring treatment (E) was applied to the landing on Block 2, which had more excavation. Treatments A, B, and E were applied to road segments, giving two replicates of each road treatment. The depth of amendments were determined based on an estimate of the amount of material that was expected to be available in the piles and are typical of what would be available operationally. One road segment and one landing plot were left as untreated controls to be planted as is. Figures 1 and 2 provide layout details.

All plots were planted with lodgepole pine in 1999.

Supervision and Documentation

The treatments were installed in the fall of 1998, and the work was supervised by Forest District staff. Notes were taken on while the work was carried out. Very little time and effort were required to install this operational trial beyond the prescribed rehabilitation work.

Follow-Up Measurements and Reporting

The effectiveness of the treatments in improving soil properties will be evaluated during field visits by research and forest sciences staff in 1999 and 2000. Simple measurements will be taken to evaluate depth of soil decompaction and depth of amendment. Samples may be collected to determine soil bulk density and organic matter content. Tree survival and growth will be determined every year or two for the first five years following planting, and then at longer time intervals. In later years, some trees may be excavated to evaluate root growth.

Example 2: Maryanne Creek (Invermere Forest District)

At the Maryanne Creek site, a large flat landing with calcareous soil was scheduled for rehabilitation to restore growing site, because the landing was no longer needed. Separate topsoil and burned debris piles were present on the landing. A small area was to be left unrehabilitated for potential re-use as a landing.

Maryanne Creek is located in the IDFdm2, in an area of SiL to SL alkaline soils derived from glaciofluvial materials and till.

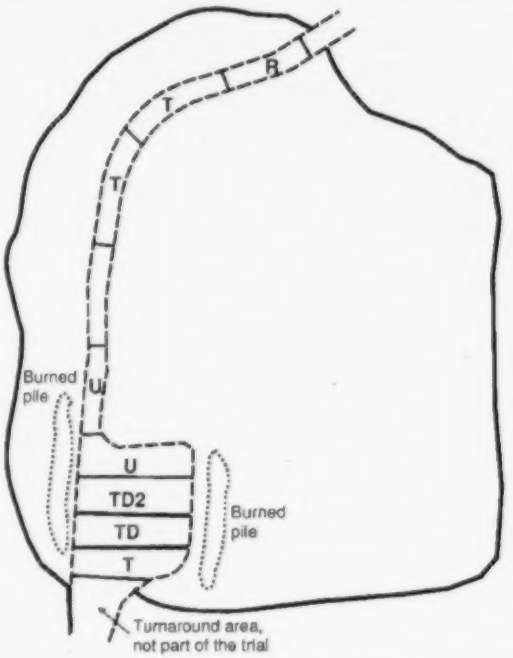

Figure 1. Layout of operational soil-rehabilitation trial at Lamb Creek: Block 1.

Table 2. Descriptions of treatments at Lamb Creek site.

Treatment	Description
U	No treatment. Plant as is.
T	Till only. Excavator decompacts the soil to a depth of 30 cm.
TB	Till, plus spread thin layer of debris/ash/topsoil. I.e., Treatment A plus re-spread an approx. 7-cm-thick layer of burned debris/topsoil.
TB2	Till, plus spread thick layer of debris/ash/topsoil. I.e., Treatment A plus re-spread an approx. 15-cm-thick layer of burned debris/topsoil.
R	Full re-contour. I.e., outsloping decompaction of running surface, pull back sidecast and topsoil (if present) to restore original soil profile as much as possible.

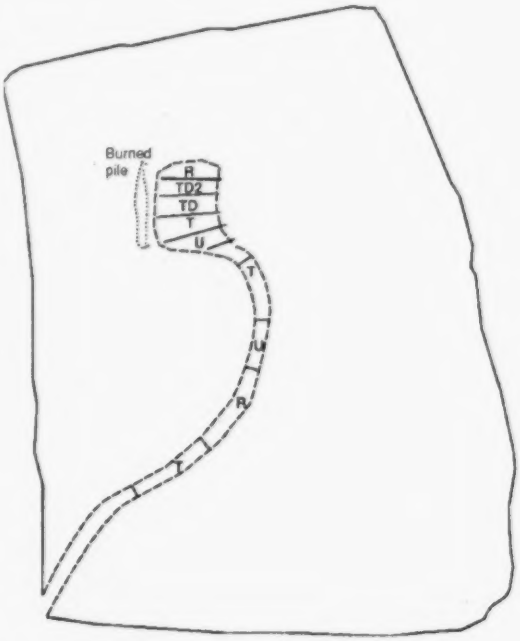

Figure 2. Layout of operational soil-rehabilitation trial at Lamb Creek: Block 2.

Setting Objectives

Burning of debris piles on landings is very common, but topsoil salvage and respreading is a relatively new technique which increases the cost of rehabilitation. Information is needed about the relative growth benefits associated with these practices, compared to simply decompacting the landing.

General Question: The general question that could be asked is:

"What are the benefits of ripping combined with soil amendments like burned soil / ash, and topsoil for rehabilitation in this area?"

Specific Question: The general question was addressed by focusing the study on the following specific question:

What are the growth rates of trees planted on soils that have been decompacted and amended with either ash / burned soil or topsoil, compared to growth rates on soils that were simply decompacted?

Site Selection and Experimental Design

After a portion of the landing was identified to be left for future use, seven plots were located. Because there were no other landings in the area that required rehabilitation, and because the initial conditions across the landing area were considered to be homogeneous, replicate plots of each treatment were laid out on the one landing as described in Table 3.

Plots receiving Treatment C were located near the burnpile, and plots receiving Treatment D were located near the topsoil pile. Because the landing was uniform, locating the plots in this way did not compromise the experiment. Figure 3 provides the layout details.

All plots were planted with lodgepole pine in 1999.

Supervision and Documentation

The treatments were installed in the fall of 1998, and the work was supervised by Forest District staff. Notes were taken while the work was carried out.

Follow-Up Measurements and Reporting

The effectiveness of the treatments will be evaluated by research and forest sciences staff in 1999 and 2000. Simple measurements will be taken to evaluate depth of soil decompaction and depth of amendment. Samples may be collected to determine soil bulk density and organic matter content. Tree survival and growth measurements will be made every year or two for the first five years following planting, and then at longer time intervals. Some trees may be excavated for root growth evaluation in later years.

SUMMARY

Operational trials provide an effective way to address information needs in soil rehabilitation. By working together to set objectives, select sites, supervise treatments, and monitor the effects, operational staff and researchers can ensure that limited resources are used most effectively to develop new knowledge in soil rehabilitation.

This note has summarized some of the major features of operational trials as they are used in soil rehabilitation. The examples have provided specific information on how a trial could be set up in the field.

Table 3. Descriptions of treatments at Maryanne Creek site.

Treatment	Description
U	No tillage, no amendment. Plant as is.
TB	Till, plus burn pile debris. I.e., Treatment A plus spread burned debris.
TS	Till, plus spread a 10-cm layer of topsoil. I.e., Treatment A plus spread topsoil.

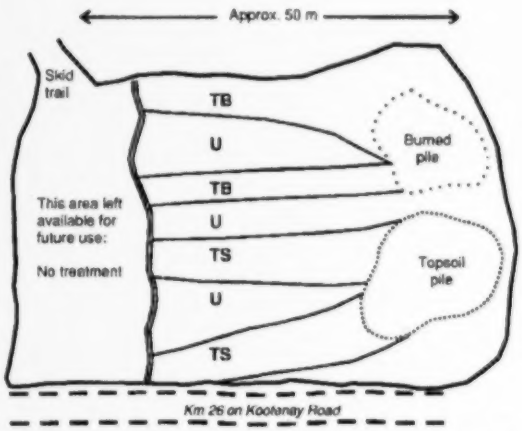

Figure 3. Layout of operational soil-rehabilitation trial at Maryanne Creek.

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